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## AN EVALUATION OF ECONOMISTS' INFLUENCE ON ELECTRIC UTILITY RATE REFORMS

Jan Paul Acton \*

The 1970s will go down as the decade when American electric utilities discovered time of use (TOU) pricing. Its strong theoretical foundation and its successful application in European utilities appealed to economists, and dramatic changes in short- and long-run costs around this time presented an institutional opportunity for change. The late 1960s marked the end of declining real costs, and after 1973 many utilities saw their fuel bills climbing from 10 or 20 percent of their annual costs to over 50 percent of their total costs, with retail rates following closely. There was strong pressure to do something.

This paper traces the role economists played in getting data, analyzing data, and evaluating alternative rate structures. In an attempt to assess the effectiveness of economists in this process, I focus on how our profession influenced the arguments put forth and the nature of the evidence used in the debate--not on whether the outcomes in terms of rates were those proposed or preferred by economists.

Time of day rates were very rare in the United States in the early 1970s. A few of the larger commercial and industrial customers faced rates with an off peak waiver in the demand (kw) charge. A small number of residential customers took part of their service under a special rate that allowed reduced costs for loads controlled by timers or under the remote control of the electric utility.

By 1981, the picture had changed substantially. The Public Utilities Regulatory Policy Act (PURPA) of 1978 required all 50 state utility commissions and more than 150 other jurisdictions regulating electric utility rates to consider the "cost effectiveness" of 11 ratemaking standards, including time

of day and seasonal rates for all classes of customers. At the state level individual electric utilities were required to consider and offer fundamentally new rate structures. By 1981, well over 13,000 large commercial and industrial customers, and an even greater number of residential customers, faced time of day rates for their electricity.

Setting aside the measurement of costs and optimal pricing rules, the discussion of TOU pricing focused primarily on whether new rates would affect the quantity and timing of energy use and whether the rates were desirable in some benefit/cost sense. Probable demands under alternative rate structures had to be estimated and appropriate evaluation criteria applied. I review the economists' contributions to these efforts in two areas: (1) evidence of TOU rate effects on residential customers and (2) the choice and application of suitable evaluation criteria to alternative rate structures.

While economists actively participated in both of these areas, as a profession I feel we fell far short of the contributions we could have made in influencing the nature of the analytic questions raised and the evidence brought to bear. However, several topics still seem ripe for contributions by economists.

#### I. EVIDENCE OF TOU RATE EFFECTS ON RESIDENTIAL CUSTOMERS

The major source of information on residential price effects has been the 15 rate demonstrations conducted between 1975 and 1980. These studies display a considerable range of sophistication in their design, number of customers covered, and quality of analysis. The Federal officials who initiated the program said that their primary objective was to promote a discussion between utilities, regulators, and other interested parties on the subject of rate design. There was not a strongly scientific orientation; it was not even clear if they intended the studies to lay a basis for evaluation of alternative rate forms or for forecasting the magnitude of

expected impact on the timing and quantity of electricity used.

Nonetheless, these experiments have provided the principal empirical data for quantitative estimates of residential time of day forecasts, and I discuss them in terms of the quality of their experimental design, their limitations in implementation, and the character of the empirical approaches taken.

#### A. Quality of Design

An economist approaching a social experiment in time of day electricity pricing might expect that the study would (1) estimate demand curves by time period, (2) lead to the measurement of changes in welfare associated with alternate rate structures, (3) allow for a variety of rate levels and pricing periods, (4) permit accurate forecasting in the range of future levels of electricity rates, and (5) account for other factors so that predictions could be made in other service territories or under different circumstances. Unfortunately, all but a few of the 15 studies have deficiencies in one or all of these dimensions. More than half of them have such a limited experimental design that a demand curve cannot be estimated--identified in own and cross prices by period. Consequently, the analyst cannot predict demand under any TOU rates except those used in the experiment or estimate changes in consumer surplus that are associated with rate changes. The majority of the experiments chose revenue-neutral combinations of peak and off peak rates; thus at unchanged levels of utilization, the typical customer's bill would be the same as his bill under the current non-time of day rate. Revenue neutrality, however, prevents measuring an overall elasticity of demand for electricity with respect to its average price, or the prediction to other circumstances in which the average price of electricity is different. In many studies, other controlling

variables--such as weather or appliance ownership--are not accurately known.

Economists reviewing the experiment generally agree that less than half of these studies provide a solid basis for analysis and prediction; see Hill et al, Hendricks and Koenker, and Aigner. Aigner classifies them according to whether they have single or multiple rates (and therefore are potentially able to estimate demand curves) and according to whether they are of interest or generally should be ignored for other reasons (for example, concerns about the validity of the statistical sampling or lack of other important information). He determines that five of these studies have a single rate, but are to be ignored; three have a single rate but are of interest; one has a multiple rate but should be ignored; and six have multiple rates and are of interest.

The reasons for some of these fundamental limitations are varied. In many cases, the individuals responsible for the design and implementation simply were not interested in producing general purpose results. They took at face value the notion that they were to "demonstrate" a time of day rate. In other cases, economists or statisticians familiar with the experimental design literature were involved in the early stages, but were constrained by the utilities or the regulators in the features of the experiment. For example, the utility often dictated the sample size, number of candidate rates that could be offered, or choice of pricing periods. In some cases, as a matter of experimental ethics, utility officials and regulators decided that they could not simultaneously (a) have a mandatory study, (b) deny participation payments to experimental households, and (c) raise the overall cost of electricity. Another reason for limits on experimental design was the particular analytic interest of individuals responsible for the overall design. Some researchers chose to emphasize analysis of variance techniques in order to maximize the contrast between control and "treatment" customers;

As members of the profession, however, I feel we economists must accept some responsibility for the experimental design limits that cannot be attributed to institutional constraints. Even the experiments where economists were involved at the design stage often proceeded in apparent ignorance of their intellectual predecessors in other social experiments. The optimal design contributions of Conlisk and Watts, developed in the late 1960s for the negative income tax experiments, were used in only two designs. Also generally overlooked were the lessons from England's five-year electricity rate study: rate combinations selected in 1968 were no longer applicable to prevailing conditions when the study was concluded in 1973; (Boggis). Yet, many U.S. rate experiments selected experimental prices such that post-experimental predictions had to be made beyond the range of observations. These deficiencies--along with the lack of independent variation in peak and off-peak prices--should not be repeated in future experiments.

A variety of sampling, survey, and data processing considerations are important to the successful implementation of these social experiments. The most important contribution to social experiments came from Morris in the health insurance experiments. However, because his contribution was virtually contemporaneous with the design of the rate experiments, it was applied only to the Los Angeles study. Morris observed that the assignment of individual households to experimental treatments could also be treated as a matter for optimization. Whereas in classical sampling and experimental assignments the statistical properties depend on infinite sampling, in any actual experiment, a finite number of individuals, with known characteristics, are assigned to specific treatments. By knowing



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the characteristics of households assigned to individual treatments, the expected statistical precision can be improved--either to achieve greater power on the tests of certain hypotheses or to assure balance with respect to unmeasured factors. Most experiments employed random sampling or stratified random sampling to draw their study population and assigned individual households to experimental treatments and control groups randomly.

Although most experiments collected both survey information and information about weather, remarkably, part or all of this information is not included in the majority of their reports. Limited demographic information (for instance, appliance ownership or household characteristics) is contained in the regression or analysis of variance, and weather is generally not entered parametrically in the empirical analysis. However, when it is considered explicitly, weather almost always played a major role in explaining variations in observed electricity usage and is needed for prediction elsewhere.

The other major drawback in the conduct of experiments or in the preparation of analytic data files involved the treatment of price when seasonal changes occurred in the experimental rates. A number of the experiments changed either rating periods or price levels from one season to another. Customers generally switched from winter to summer prices on a different day of the month depending on when the meter was read. Failures in data handling or customer communication has led to substantial data losses in several studies because one or more month's observations was dropped in the spring and in the fall due to ambiguity in the prices. Economists interested in results should avoid such design complexities or assure that such major data losses do not occur.

### C. Nature of Findings

The principal contribution of the rate experiments to measuring economic variables is for own- and cross-price elasticity of demand by time of day. Initial reports indicated a highly disparate set of findings,

with apparent own-price elasticities in peak periods ranging from zero in the North Carolina study to well in excess of  $-1.0$  in Arizona, with the majority between  $-.4$  and  $-.85$ . Subsequent analysis by Aigner and Poirier, Hendricks and Koenker, and Aigner made it clear that the apparent differences were generally due to analysts having measured different concepts. Some authors (implicitly or explicitly) measured "partial" elasticities (effectively holding total expenditure for electricity constant) while others measured "full" elasticities (allowing for the effect of the aggregate price of electricity on each period's consumption as well). Frequently, authors did not distinguish between compensated and uncompensated elasticities as well. Hendricks and Koenker point out that for probable values of the aggregate price elasticity, income elasticity, and share of expenditure on electricity, the partial elasticity in any period will be more elastic than the full elasticity, and the compensated partial and compensated full elasticities are likely to be very close to one another (and to the uncompensated full elasticity).

Somewhat belatedly economists have agreed that full elasticities are needed for most forecasting and evaluation work. But few of the experiments were designed to yield directly a full price elasticity or an aggregate demand elasticity which can be combined with partial elasticities to produce the desired measure. Hendricks and Koenker use an assumed value of  $-.1$  for the aggregate price elasticity and calculate full own price elasticities from four sets of experimental results; Kohler performs a similar exercise using a measured aggregate elasticity of  $-.18$  from the Los Angeles experiment. Aigner compared partial uncompensated elasticities with partial compensated elasticities. Each study finds that the peak period own price elasticities shrink to a much narrower range of values, generally lying between  $-.1$  and  $-.3$ . This conclusion carries across a variety of demand models, including "simple" and highly

structured "neo-classical" models.

## II. EVALUATION

Economists evaluating TOU rates would likely conclude that more complicated rate structures are desirable as long as they reflect the underlying costs of supply and as long as the benefits exceed the implementation costs (most notably metering and increased administrative costs associated with the more complex rate structure). The "cost effectiveness" language of PURPA suggests such an evaluation criterion based on long term considerations without detailing the components of benefit; see Joskow. Individual hearings under PURPA have generally employed three standards: fuel or energy savings (if a TOU rate saves fuel or reduces total consumption, it is desirable by this standard), the effect on revenue (if a TOU rate raises more revenue, it is desirable), or welfare economics (if it produces a net gain in producer's plus consumer's surplus, it is desirable). The formal welfare economic criterion seems to be the least frequently employed standard and fuel or energy savings most commonly applied--although it has been criticized by a number of economists for its limitations and inaccuracies; Acton and Mitchell (1981), Berg.

The desirability of using a welfare standard is clear to most economists who have approached this problem, but economists have generally contributed qualitative rather than quantitative advice--perhaps because of a lack of quantitative information on which the estimates of changes in consumer surplus could rest. Wenders and Taylor recommended that time of day rates be adopted only if they provided a gain in welfare (net of incremental metering costs) over seasonal rates, and speculated that seasonal rates would exhaust most of the potential welfare gains for residential customers in many areas. When economists have quantitatively compared welfare gains under both seasonal and time of day pricing, the welfare improvement for seasonal pricing (even assuming zero implementation costs) are small, and time of day pricing still offers a

notable improvement for a part of the residential class; Lillard and Acton. Acton and Mitchell (1980) consider a number of dimensions under which customers might be relatively easily classified in order to determine when, on average, benefits exceed costs. They find that customers at higher levels of use (over a 1100 kwh per month), customers with greater stocks of appliances, and customers with particularly price responsive appliances (notably air conditioning and swimming pools) are all likely to be net beneficiaries of time of day rates under circumstances that apply in Los Angeles. For lack of quantitative alternatives, these results have sometimes been employed in utilities with quite different characteristics.

### III. CONCLUSION

As a profession we can view the contributions of economists to these electricity rate changes with mixed emotions. On the one hand, TOU pricing is clearly established as a feature of U.S. ratemaking, and an economic forecast of price effects is now a routine part of rate deliberations. On the other hand, I feel we did not contribute as much as we could have to the data that were generated and the analysis provided.

New TOU rates were introduced for large commercial and industrial customers in the absence of clear quantitative evidence of the magnitudes of expected impact (both in terms of changed kwh consumption and change in consumer surplus). Utility commissions generally took the position--which I find reasonable--that time of day rates more accurately reflect the costs of supply of electricity under different circumstances and that the metering costs were trivial compared with the potential gains for this group of customers. They often require that evidence of benefit be offered before the rates will be extended to other commercial and industrial customers--a tribute to the importance of demand analysis--but the initial step generally was made without that evidence.

For residential customers, our contributions were also less than they could have been. Due to limited experimental design, the majority of rate experiments were not up to the task of either estimating demand curves or measuring changes in consumer welfare. Economists have fallen into their traditional role of applying sophisticated analytic techniques to data already developed by other researchers. The application of highly structured systems of demand equations--consistent with utility maximizing behavior by customers--is sometimes able to pull information out of a statistically under-identified experimental design, but many key assumptions cannot be tested. Similarly, although it helps to apply analytic techniques for selectivity bias or truncation bias caused by experimental designs that protected households from paying more for electricity under experimental rates than under prevailing rates, it would have been better if the problem had been avoided at the outset.

When price elasticities were provided, early reports did not distinguish partial from full price elasticities, and the values reported ranged from zero to well in excess of -1; this range of numbers could support virtually any conclusion that a policymaker cared to draw. Somewhat belatedly, we have reached agreement on the appropriate measures that are needed and the values have converged considerably, but it is too late to influence the data that were generated.

Finally, economists have a major opportunity to contribute to the evaluation of new rate forms for both larger customers and residential customers. We should be prepared to help policymakers answer these fundamental questions: Should more complicated rate structures be offered on an optional or mandatory basis? What convenient criteria are available for sorting customers into groups that are likely (or unlikely) to benefit from new rates? How complex should the rate structures be (in terms of rating

periods as well as multipart and nonlinear pricing structures)? and Can reasonable welfare evaluations be made when empirical data on the nature of underlying demands are limited?

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FOOTNOTE

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